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Appendix

1. Introduction

This report identifies and provides technical justification for the selection of upgradient wells for use in monitoring groundwater quality in the Shallow Zone at the Eastside area of the Basic Management, Incorporated (BMI) Common Areas/Complex (the "Site") in Clark County, Nevada (Figure 1). Proposed existing wells are identified to be used for upgradient monitoring purposes, and the rationale and criteria used to propose the wells are presented and discussed.

The scope of work for this report has previously been discussed between Basic Remediation Company (BRC) and Nevada Division of Environmental Protection (NDEP) representatives, in an NDEP meeting on February 4, 2009 and in written correspondence to BRC dated February 20, 2009. Preliminary NDEP comments dated January 8, 2010 regarding the draft of this report dated December 30, 2009 are addressed in this revised report (Appendix A); Appendix A also includes **responses to** NDEP comments dated August 5 and 7, 2009**,** regarding the July 24, 2009 draft of this report**, and responses to NDEP comments dated February 20, 2010, regarding the February 11, 2010 draft of this report**.

1.1 Location and Setting

The Site is located in Clark County, Nevada, and is situated approximately 2 miles west of the River Mountains and 1 mile north of the McCullough Range. As shown in Figure 1, the area surface topography slopes in a westerly to northwesterly direction from the River Mountains and in a northerly to northeasterly direction from the McCullough Range. Near the Site, the surface topography slopes in a northerly direction toward Las Vegas Wash.

The uppermost water-bearing zone (referred to as the Shallow Zone) is unconfined and occurs primarily in Quaternary alluvium (Qal). At some locations on portions of the Site, Shallow Zone groundwater is first encountered in the uppermost portion of the Tertiary Muddy Creek Formation (TMCf). This unconfined Shallow Zone groundwater generally flows in a northerly direction toward Las Vegas Wash. The Shallow Zone groundwater is generally continuous across the Site, but there are areas where Shallow Zone wells are dry. **To distinguish between unconfined groundwater occurring in the two lithologies, the Shallow Zone is further divided into Layer 1 (Qal only) and Layer 2 (TMCf only).**

Below the Shallow Zone, deeper groundwater occurs in sporadically encountered lenses under pressure in the Middle Zone, designated between approximately 90 and 270 feet below grade. A coarser-grained facies of the TMCf occurs off-site and in the southwest portion of the study area (at Location 27, for example). The proportion of coarser-grained sediments in the upper portion of the TMCf decreases to the north beneath the Site. This more permeable TMCf facies is interpreted as being caused by an influx of slightly coarser alluvial deposits into the older lacustrine depositional environment. One possible ramification of the presence of these coarser TMCf sediments near the southwestern border of the Site is that they may serve as a potential pathway for chemicals to migrate into the TMCf.

Deep Zone groundwater is generally continuous across the Site and is characterized with wells screened below 270 feet below ground surface (ft bgs) to a maximum nominal depth of 400 ft bgs. Groundwater elevation data from the last several rounds of groundwater monitoring (2006 through 2009) show that Deep Zone groundwater is confined, and the potentiometric surface of Deep Zone groundwater is oriented generally north toward Las Vegas Wash (MWH, 2008).

Vertical gradients at the Eastside area, as measured in the six Eastside monitoring events, have been generally upward. A summary table and figure of vertical gradient data is presented in the BRC report entitled, *Evaluation of Hydrogeologic Zone Connectivity Through Tritium and Stable Isotope Sampling and Analysis*" dated December 29, 2009 (DBS&A, ~~2009b~~**2010**).

The generally upward gradient condition is consistent with the position of the Site at the relatively distal end of two coalescing alluvial deposits from the McCullough Range and the River Mountains. In general, high-energy alluvial sediments are deposited near their source, resulting in a geologic profile dominated by coarser-textured soils that are conducive to downward recharge of precipitation and mountain runoff. At more distal locations, it is common to encounter lower-energy alluvial sediments that result in a geologic profile dominated by finer-textured soils. The distal portions of alluvial deposits often comprise pressure zones where confining or semiconfining zones exist. Water in these zones is often laterally recharged at depth, resulting in pressure buildup that is sustained by the head of water created in the upslope vertical recharge zones. At more proximal locations, such as the off-site plants area, the gradient would be expected to be more typically downward. For example, downward vertical gradients have been measured in well pairs AA-01/MCF-01B (DBS&A, ~~2009b~~**2010**).

Separate NDEP-approved project documents provide further information regarding area geology and hydrogeology, soils, history, and investigations completed to date (e.g., BRC et al., 2007; DBS&A, ~~2009b~~**2010**).

1.2 Objective

The objective of this report is to present and justify the criteria used in the selection of the upgradient wells for monitoring groundwater quality in the Eastside area. Upgradient wells need to be designated at the Site in order to document and evaluate the quality of groundwater flowing onto the Site from off-site areas. Data from the upgradient wells can then be compared to data from on-site wells, along with comparison to state and federal water quality standards, to assist in the evaluation of Site impacts. Upgradient well data will also be used, in part, for remedial decision-making. As discussed in Section 2.1, it is not possible to install background monitoring wells at this Site. As a result, proposed upgradient wells will be used for data evaluation.

2. Upgradient Well Selection

The upgradient wells are located according to the following selection criteria:

- Hydraulically upgradient
- Along the majority of the upgradient site boundary
- Where off-site upgradient groundwater impacts, if present, are well characterized

Proposed upgradient wells must also be properly constructed to represent the hydrogeologic zone of interest. To qualify as Shallow Zone upgradient wells at the Site, the proposed wells must be adequately screened in the Shallow Zone. At the Eastside area, the following wells meet the criteria listed above (Figure 2) (Appendix B):

- AA-01
- AA-27
- AA-UW-1
- AA-UW-2
- AA-UW-3
- AA-UW-4
- AA-UW-5
- AA-UW-6

2.1 Groundwater Occurrence and Flow Direction

Figure 2 presents a regional map of the Shallow Zone potentiometric surface at the Site based on 2009 data. As discussed in Section 1.1, Shallow Zone groundwater occurs in **both** the Qal and the uppermost TMCf at the Site~~.~~ **and is therefore further divided into Layer 1 (Qal only) and Layer 2 (TMCf only).** Flow direction in the Shallow Zone is directed generally to the north toward Las Vegas Wash.

Flow direction has been roughly consistent over the last several rounds of water level measurement at the Site, completed in 2006, 2007, 2008 (MWH, 2008) and 2009. As shown on Figure 2, the proposed upgradient wells are located at the southern, southwestern, and southeastern boundaries of the Eastside area, and are well distributed along the Site perimeter in this area. This portion of the Site perimeter is the upgradient boundary of the Eastside area.

Several soil borings were completed in the off-site upgradient areas as part of the background metals investigation (BRC and ERM, 2009a) (Appendix B). Based on these borings, it appears that Shallow Zone groundwater occurs at much deeper depths further upgradient and ~~the Shallow Zone~~ is absent **in the Qal** further upgradient to the east. **This relationship is illustrated in Figure 3, which shows a cross section through well AA-UW-6 to the northwest and southeast.** As identified by wet soil logged in the field, groundwater was encountered in only 2 of the 23 borings. Groundwater was encountered at 140 ft bgs in boring DBSA-17 and at 84.7 ft bgs in boring DBSA-20.

The other background metals soil borings (except DBSA-33) were drilled between 80 and 160 ft bgs, but only moist soil was logged (boring DBSA-33 was terminated at 32.5 feet when the TMCf was encountered). Since groundwater occurs at deeper depths further upgradient and off-site, additional wells installed in these areas would likely be screened in a different hydrogeologic unit than the existing on-site wells. The proposed upgradient wells are screened in the same hydrogeologic unit as on-site Shallow Zone wells (Table 1, Appendix B). **Proposed upgradient wells AA-UW-1, -2, -4, -5, and -6 are installed in Layer 2 of the Shallow Zone (screened in the TMCf only), in which groundwater first occurs along the eastern Site boundary. Wells AA-01, AA-27 and AA-UW-3 are screened in Layer 1 (Qal only), in which groundwater first occurs along the western Site boundary.**

Appendix C (Figure C-1) contains a 2006 regional groundwater flow map prepared by TIMET (2007) that covers the Eastside area as well as adjacent properties upgradient to the south and west. The direction of groundwater flow in the regional flow map is also oriented generally to the north toward Las Vegas Wash.

Upgradient anthropogenic complexities introduced in the BMI Complex over the years (such as barrier walls, extraction well fields, and injection trenches) may have altered

groundwater flow patterns. It is also noted that deep drilling, sampling, and well completion beneath the Qal/TMCf contact in the BMI Complex has been sparse. Thus, only limited conclusions can be drawn regarding whether deeper chemical impacts and flow paths within the BMI Complex may be affecting chemical transport in the region.

Based solely on elevation, the upper Middle Zone at the plants area corresponds to the Shallow Zone at BRC Eastside, because the plants area is topographically higher than the BRC Eastside property. That is, 130 feet below grade at the plants area, which is approximately 1,700 feet in elevation above mean sea level, corresponds to approximately 50 feet below grade at the Eastside property. As a result, Middle Zone and Layer 2 Shallow Zone impacts at the plants area may be contributing to Shallow Zone Layer 1 impacts at the Eastside. As discussed in the revised isotope report dated April 21, 2010 (DBS&A, 2010), the plants area is located closer to the regional recharge area, while the BRC Eastside is located in the "pressure area" (Figure 4).

2.2 Historical Site Use and Facility Operations

Historical site use and facility operations are detailed for the Eastside area in the 2007 Closure Plan (BRC et al., 2007) and in other related BRC documents. As described in the Closure Plan (BRC et al., 2007) the Eastside area covers approximately 2,321 contiguous acres. The Eastside area lies to the east of Boulder Highway and to the north of Lake Mead Parkway and includes land on which:

- Unlined wastewater effluent evaporation/infiltration ponds (and associated conveyance ditches) were built and into which various plant wastewaters were discharged from 1942 through 1976.

- Effluent from the adjacent TIMET plant was disposed of through the use of a spray irrigation wheel used between 1985 and 1990.

- Lined wastewater effluent ponds were constructed, into which effluent from the TIMET plant was discharged from 1976 to 2005.

- The City of Henderson constructed municipal wastewater infiltration basins (e.g., the Southern rapid infiltration basins [RIBs]).

- Unlined wastewater effluent ponds were constructed, but were never used.

The proposed upgradient wells are generally located within those areas of the Site that were not used for the operations described above. The land in the vicinity of the upgradient wells has remained primarily open desert, with relatively minor adjacent property development for residential or commercial (non-industrial) use. Upgradient wells AA-UW-5 and AA-UW-6 are relatively close to the southern boundary of the upper ponds. Wells AA-01 and AA-UW-1 are relatively close to the now-closed TIMET ponds that were built on top of the former upper ponds. Wells AA-01, AA-UW-1, and AA-27 are adjacent to the active BMI Complex.

Appendix C provides selected information extracted from various reports and documents that summarize off-site source information for the plants area upgradient to the south and west. Included in Appendix C is a regional map from 2006 that shows flow from the plants area toward proposed upgradient wells AA-01 and AA-27. A regional map of arsenic detections in groundwater (from various dates) is also included that shows arsenic impacts originating at the plants area. Regional plume maps (2006) for nitrate, chloride, sulfate, total dissolved solids (TDS), and selected metals and volatile organic compounds (VOCs) are also included. A map and table summarizing Tronox (formerly Kerr-McGee Chemical LLC) source areas is included for reference. As discussed in Section 2.4.3, the plants area is interpreted to be the likely source for some of the groundwater impacts detected in the proposed upgradient wells.

2.3 Modeling Results

BRC submitted a draft groundwater flow model calibration report to the NDEP in 2009 (DBS&A, 2009~~a~~) (subsequently approved by NDEP). An evaluation of the potential historical mounding was completed using the updated flow model. Pond recharge was estimated at 48.18 inches per year (Figure ~~3~~**5**). Heads were simulated for this condition to produce a groundwater flow map representing the period of time that the lower ponds were in use (Figure ~~4~~**6**). The simulation indicates that groundwater flow was oriented primarily to the north near the locations of upgradient wells AA-01, AA-UW-1, AA-27, AA-UW-2, AA-UW-3, A-UW-4, and AA-UW-5. The simulation also indicates that localized mounding is present at the lower ponds, and flow is radial for a small area around the ponds. The location of well AA-UW-6 appears to be marginally within the area of the localized mounding.

The remaining upgradient wells are located outside the area of modeled localized mounding caused by pond use. Flow direction near the former ponds and at well AA-UW-6 has since returned to its original northwesterly direction (Figure 2, Figure C-1). As discussed in Section 2.4, the soil and groundwater data from well AA-UW-6 do not appear to reflect unique impacts due to former pond use.

2.4 Soil and Groundwater Impacts

Selected analytical data for the upgradient well locations are discussed below in Sections 2.4.1 through 2.4.3.

2.4.1 Soil Data for Metals

The background metals dataset for the Eastside area (BRC and ERM, 2009a) was compared to the range of metals concentrations data collected from the upgradient well locations (Appendix D) (excluding duplicates). The following metals from the Site-related chemicals (SRC) list were evaluated:

- Radionuclides
  - Radium-226
  - Radium-228
  - Thorium-228
  - Thorium-230
  - Thorium-232
  - Uranium-233/234
  - Uranium-235/236
  - Uranium-238

- Metals
  - Aluminum
  - Antimony
  - Arsenic
  - Barium
  - Beryllium
  - Boron
  - Cadmium
  - Calcium
  - Chromium (VI)
  - Chromium (total)
  - Cobalt
  - Copper
  - Iron
  - Lead
  - Lithium
  - Magnesium
  - Manganese
  - Mercury
  - Molybdenum
  - Nickel
  - Niobium

In accordance with the BRC Closure Plan (BRC et al., 2007), background metals comparisons were performed using the Quantile test, Slippage test, t-test, and Wilcoxon Rank Sum test with Gehan modification. The Quantile test, Slippage test, and Wilcoxon Rank Sum test are nonparametric; that is, the tests are distribution-free, and an assumption of whether the data are normally or lognormally distributed is therefore not necessary. The computer statistical software program Guided Interactive Statistical Decision Tools (GISdT) (Neptune and Company, 2007) was used to perform all statistical comparisons, with a decision error of alpha equal to 0.025.

The Wilcoxon Rank Sum test analyzes the difference between the ranks for two populations. This is a nonparametric method of assessing differences in the centers of the distributions that relies on the relative rankings of data values. Knowledge of the precise form of the population distributions is not necessary. When the data are normally distributed, the Wilcoxon Rank Sum test has less power than the two-sample t-test, but the assumptions are not as restrictive. The GISdT version of the Wilcoxon Rank Sum test uses the Mantel approach, which is equivalent to using the Gehan ranking system (Neptune and Company, 2007).

The Quantile test addresses tail effects that are not addressed in the Wilcoxon Rank-Sum test. The Quantile test looks for differences in the right tails (upper end of the dataset) rather than central tendency as the Wilcoxon Rank-Sum test does. The Quantile test was performed using a defined quantile equal to 0.80 (Neptune and Company, 2007).

The Slippage test looks for a shift to the right in the extreme right tail of the background dataset versus the extreme right tail of the site dataset. This is equivalent to asking if a set of the largest values of the site distribution are significantly larger (in a statistical sense) than the maximum value of the background distribution (Neptune and Company, 2007).

Typically, an alpha equal to 0.05 is used to evaluate a statistically significant result (Neptune and Company, 2007). Since several correlated tests were conducted, a lower alpha was selected. As more tests are performed, it is more likely that a statistically significant result will be obtained purely by chance. Given the use of multiple statistical tests, an alpha equal to 0.025 was selected according to NDEP guidance (NDEP, 2009a) as a reasonable significance level (p).

If an individual test p-value is less than 0.025, the test result is interpreted to indicate that the metal exceeds background levels. Additional factors, such as detection frequency and mean or median values, are also reviewed to determine if a metal exceeds background levels.

Metals data from the upgradient well borings and nearby soil borings SB-01 and SB-27 were sorted into the following groups based on sample depth and the geographic location of the boring:

- Shallow Qal (samples from less than 20 ft bgs): Data were compared to the Shallow McCullough dataset, the Shallow Mixed dataset, or the Shallow River dataset.

- Deep Qal (samples from greater than or equal to 20 ft bgs, but collected above the contact between the Qal and Upper Muddy Creek formation [UMCf]): Data were compared to the Deep McCullough dataset, the Deep Mixed dataset, or the Deep River dataset.

- TMC (samples collected from the UMCf (below the Qal/TMCf contact): Data were compared to TMC dataset.

The River datasets represent background metals characterized from soils collected in the shallow alluvial fan system originating in the River Mountains to the east of the Site. The McCullough datasets represent background metals characterized from soils collected in the shallow alluvial system originating in the McCullough Range to the south/southwest of the Site. The Mixed datasets represent background metals characterized from soils collected in the shallow alluvial system originating from both the River Mountains and the McCullough Range, where the two fan systems coalesce.

Data from upgradient well boring AA-UW-5 were compared to the Mixed datasets because this boring is located where the River Mountains alluvial fan system and the McCullough Range fan system coalesce. Data from upgradient well boring AA-UW-6 were compared to the River datasets because this boring is located within the River Mountains alluvial fan system. All other borings (including soil borings SB-01 and SB-27) fall within the McCullough Range fan system, so these remaining data were compared to the McCullough datasets (BRC and ERM, 2009a). Deep data below the Qal/UMCf contact were compared to the TMC dataset.

2.4.1.1 Shallow Metals (less than 20 feet below grade)

The shallow background metals comparison for upgradient well borings AA-UW-5 (Shallow Mixed dataset) and AA-UW-6 (Shallow River dataset) could not be completed because, with only two samples per boring (not a total of four in a usable set), there is an insufficient number of detections to use for the statistical calculations.

The background metals comparison for the upgradient well borings falling into the McCullough grouping (all borings except AA-UW-5 and AA-UW-6) indicates that the following metals were detected above background:

- Boron
- Chromium (VI)
- Total chromium
- Iron
- Niobium
- Silver
- Sodium
- Strontium
- Titanium
- Tungsten
- Vanadium

2.4.1.2 Deep Metals (greater than 20 feet below grade and above the Qal/UMCf contact)

The deep background metals comparison for upgradient well boring AA-UW-6 (Deep River dataset) could not be completed because, with only two samples in the boring, there is an insufficient number of detections to use for the statistical calculations.

In the absence of statistical analysis, a rudimentary comparison was made with the available data. For metals with reported detections, the mean and maximum detected concentrations in AA-UW-6 were compared to mean and maximum concentrations of the same metals in the Deep River dataset. The following metals detected in the AA-UW-6 soil samples exceed the mean background in the Deep River dataset:

- Cadmium
- Calcium
- Lithium
- Manganese
- Molybdenum

- Silicon
- Tungsten
- Uranium
- Radium-226
- Thorium-228
- Thorium-230

Thorium-230 is the only metal detected in the AA-UW-6 soil samples that had a maximum detected concentration that exceeds the maximum detected value in the Deep River dataset.

The background metals comparison for the upgradient borings falling into the Deep McCullough grouping (all borings except AA-UW-5 and AA-UW-6) indicates that the following metals were detected above background:

- Aluminum
- Barium
- Boron
- Chromium (VI)
- Total chromium
- Iron
- Lead
- Manganese
- Selenium
- Silicon
- Thallium
- Titanium
- Zinc

The background metals comparison for the upgradient well boring AA-UW-5 falling into the Mixed Deep grouping indicates that the following metals were detected above background:

- Silicon

- Sodium
- Strontium

2.4.1.3 Deep Metals (below the Qal/UMCf contact)

The background metals comparison for the upgradient boring data collected below the Qal/UMCf contact (all borings) indicates that the following metals were detected above background in the TMC dataset:

- Beryllium
- Boron
- Cadmium
- Chromium (VI)
- Total chromium
- Copper
- Magnesium
- Molybdenum
- Selenium
- Silicon
- Sodium
- Thallium
- Tungsten
- Uranium
- Zinc
- Radium-226
- Thorium-230
- Uranium-233/234
- Uranium-238

*2.4.1.4 **Supplemental Shallow Soil Background Dataset AA-UW-6 Comparison***

The soil metals data from boring AA-UW-6 were compared also to the background metals concentrations detected in the supplemental shallow soil background dataset (ERM West, 2009). None of the metals detected in AA-UW-6 soil samples exceeded

background metals concentrations detected in the supplemental shallow soil background dataset (Table 2).

While well AA-UW-6 has higher arsenic concentrations than downgradient wells, this well has lower concentrations for carbon tetrachloride, total and hexavalent chromium, manganese, PCE, perchlorate, Ra 226+228, selenium, and TTHMs. Well AA-UW-6 appears to be affected by upgradient sources of arsenic, but there does not appear to be an off-site source of these other analytes upgradient of AA-UW-6.

2.4.2 Summary of Metals Data Evaluation

The upgradient wells and well borings are located within BRC Parcels 4A and 4B. An investigation of soil conditions in these parcels was reported in 2008 and 2009 (BRC and ERM, 2008b, 2009b). As discussed in the investigation reports, based on the results of the investigations, data review, and a screening-level health risk assessment, exposure to residual levels of chemicals in soil at the property should not result in adverse health effects to any future on-site receptors (BRC and ERM, 2008b, 2009b). The NDEP agreed with this conclusion and agreed that development may proceed on the parcels without environmental restriction (NDEP, 2008, 2009b). However, NDEP's No-Further Action (NFA) determination for the parcels was restricted to the upper 10 feet of soil (in which relatively low metals concentrations had been measured), because deeper soil had not been evaluated.

While metals detections in soils deeper than 10 ft bgs may be representative of some residual impacts from past industrial site use in the area, these deeper soil metals detections that are excluded from the NFA should not prohibit the use of the proposed wells for upgradient data collection and evaluation.

In addition to the 2008 and 2009 investigations, pH was measured in soil samples from the upgradient well borings in 2004 and 2007 (BRC and ERM, 2008a; MWH, 2006). Data for pH was collected from borings AA-UW-1 through AA-UW-6 (10 to 80 ft bgs), boring SB-01 (0 to 93 ft bgs), and boring SB-27 (0 to 107 ft bgs). For all samples, the measured values for soil pH ranged from 7.6 to 9.6. These pH data indicate that soil conditions were not acidic in the upgradient well borings and that conditions favorable for metals reduction, mobilization, and leaching were not present.

As discussed in Section 2.4.5, soil metals concentrations detected above groundwater were screened against both the background metals datasets (Section 2.4.1) and the leaching-based Basic Comparison Levels (LBCLs) from NDEP (2010). Except for one detection of aluminum in boring AA-UW-5, all metals that exceed background concentrations fall below the LBCLs (Table 2). Metals concentrations that exceed LBCLs are all below background metals concentrations.

2.4.3 Soil Data for Nonmetals

The results of laboratory analyses for nonmetals in soil samples representative of borings located in the upgradient well areas were compared to the Nevada Basic Comparison Levels (BCLs). Because no comparison was being made to background concentration levels, there was no need to group the soil samples by depth, as was the case for the evaluation of metals in soil samples.

Table ~~2~~ **3** presents a statistical summary of nonmetals detected in soil samples collected from the upgradient well borings and adjacent borings SB-01 and SB-27. Table ~~3~~ **4** summarizes selected analyte detections for each well boring. Compounds detected in the upgradient borings include organochlorine pesticides, organophosphate pesticides, and VOCs. None of the detections, however, exceed BCLs.

Up to 2.5 milligrams per kilogram (mg/kg) perchlorate was detected at 60 ft bgs in soil boring SB-01, drilled near upgradient well AA-01 (Table ~~3~~**4**). Perchlorate was also detected at more shallow depths in this boring. Perchlorate was also detected in groundwater samples from well AA-01 and the other upgradient wells. The detected concentrations may not be Site-related and may be due to historical perchlorate use and release at adjacent upgradient and cross-gradient facilities (such as Tronox and AMPAC).

Similarly, relatively low concentrations of VOCs (less than 60 micrograms per kilogram [μg/kg]) have been detected in soil samples from the well borings (Table ~~3~~**4**). Tetrachloroethene (PCE) was detected up to 7.7 µg/kg in soil samples from borings completed near wells AA-01 and AA-UW-5. Trichloroethene (TCE), a degradation daughter compound of PCE, was not detected in soil samples from the upgradient well locations. However, both PCE and TCE have been detected in the upgradient groundwater well samples.

As discussed in Section 2.3, boring AA-UW-6 appears to be marginally within the area of former localized mounding due to pond use. Shallow groundwater flow near AA-UW-6 has since returned to its original northwesterly direction. The soil data from boring AA-UW-6 do not appear to reflect unique historical impacts from former use of the upper evaporation ponds, which is consistent with the conclusion from flow modeling that former pond use did not significantly impact soil in the area. ~~That is, nonmetals at this boring location were not detected at concentrations that are one or more orders of magnitude higher than the relatively low-concentration detections in the other upgradient well borings. In addition, as noted above, all detections are less than BCLs.~~

2.4.4 Summary of Nonmetals Data Evaluation

As discussed in Section 2.4.2, the upgradient wells and well borings are located within BRC Parcels 4A and 4B. As discussed in the soil investigation reports for these parcels (BRC and ERM, 2008b, 2009b), based on the results of the investigations, data review, and a screening-level health risk assessment, exposure to residual levels of chemicals in soil at the property should not result in adverse health effects to any future on-site receptors. The NDEP agreed with this conclusion and agreed that development may proceed on the parcels without environmental restriction (NDEP, 2008, 2009b), although NDEP's "No-Further Action (NFA)" determination for the parcels was restricted to the upper 10 feet of soil, because deeper soil had not been evaluated. While the soil nonmetals detections below BCLs may potentially represent some residual impacts from past industrial use in the area, the deeper soil nonmetals detections excluded from the NFA should not prohibit the use of the proposed wells for upgradient data collection and evaluation.

2.4.5 Metals and Nonmetals Screening Against LBCLs

The maximum metals concentrations for samples that were collected above groundwater were compared to NDEP LBCLs (dilution-attenuation factor [DAF]-20) in accordance with NDEP guidance (NDEP, 2010). These data were also compared to the background metals datasets, and the data from AA-UW-6 were further compared to the supplemental shallow soil background dataset (ERM West, 2008). (All detected iron concentrations were lower than the 54,750-mg/kg NDEP residential soil BCL and were therefore not included in the comparison.) Table 2 lists the analytes that exceeded either the associated LBCL or background concentration.

For all borings except AA-UW-5, the maximum concentration for all of the evaluated analytes was below either the background concentration or LBCL; only one aluminum detection in AA-UW-5 exceeded both. However, aluminum has not been identified as an analyte of interest (AOI) in BRC Eastside or plants area groundwater.

For the remaining data in each boring, the detected metals concentrations that exceed background fall below LBCLs, and the detected metals concentrations that exceed LBCLs (aluminum and manganese) fall below background.

Alpha-BHC, beta-BHC, and dichloromethane (one detection in AA-UW-6) are the only nonmetals in the soil data that exceed LBCLs. As shown in Appendix C, the detected alpha-BHC and manganese concentrations are likely due to the plants area alpha-BHC impacts, which are much higher in comparison. Dichloromethane has not been identified as an AOI in BRC Eastside or plants area groundwater.

2.4.6 Groundwater Data

2.4.6.1 Piper and Stiff Diagrams

Piper trilinear diagrams and Stiff polygonal diagrams of major cation and anion data from the Eastside 2009 groundwater sampling event for BRC wells are provided as Figures ~~5~~ **7** through ~~8~~**10**. As shown on these figures, the ion data show that the hydrogeochemical signature of groundwater in the upgradient wells is broadly consistent with other Shallow Zone wells screened in the same hydrogeologic unit. A relatively few Site wells, however, have a relatively distinct hydrogeochemical signature, such as off-site well PC-67 (relatively high sodium and chloride content) and well AA-18, where the ion content is relatively low. **Appendix E presents available Shallow Zone Layer 2 data from TIMET for comparison.**

An updated version of the cation-anion balance (CAB) table (with related check calculations) is provided in Appendix ~~E~~**F**. The CAB table was prepared in accordance with NDEP guidance and Standard Methods for the Examination of Water and Wastewater (Section E).

2.4.6.2 Basic Comparison Levels

All data from the groundwater samples collected from the Shallow Zone upgradient wells over the six monitoring events were compared to BCLs established by the Nevada Division of Environmental Protection (NDEP) to determine the level of chemical impact to the upgradient wells. Each of the proposed upgradient wells appear to have been impacted above the BCLs for various individual chemical constituents (Tables ~~4a~~**5a**, ~~4b~~**5b**, ~~5a~~**6a**, and ~~5b~~**6b**), including:

- 1,4-Dichlorobenzene
- Acetaldehyde
- Alpha BHC
- Arsenic
- Bromodichloromethane
- Chlorine
- Chloroform
- Chromium (VI)
- Dimethyl phosphorodithioic acid
- Fluoride
- Formaldehyde
- Iron
- Lithium
- Magnesium
- Nitrate (as N)
- Octachlorodibenzodioxin

- Perchlorate
- Phosphorus (as P)
- Tetrachloroethylene
- Thallium
- Trichloroethylene
- Uranium

Based on isoconcentration plots of chemicals presented in the monitoring reports for the six monitoring events (Appendix **G**~~F~~), the chemical distribution data appear to indicate that chemicals detected in wells AA-01 and AA-27 may be moving from off-site locations onto the Site. **Appendix G includes isoconcentration maps using available plants area data that are split into Shallow Zone Layer 1 and Shallow Zone Layer 2.**

The source of these chemicals in groundwater samples from the upgradient wells may be the historical operations in the off-site upgradient BMI Plants area. TCE was detected at less than 1 µg/L (in wells AA-01 and AA-UW-~~0~~1) in the 5th round event (Table ~~4a~~**5a**), and PCE was detected at a maximum of 84 µg/L in well AA-01 in the 5th round event (Table ~~4a~~**5a**) and at 73 µg/L in the Eastside 2009 groundwater sampling event (Table~~ 5b~~**6b**).

PCE and TCE are also documented to have been released at upgradient sites to the southwest (e.g., TIMET and Tronox) (Appendix C, Figures C-12 and C-13~~) ~~**; Appendix G)**. The information in Appendix C represents a portion of the off-site source information that is fully detailed in the TIMET *Conceptual Site Model Report* (TIMET, 2007) and the Kerr-McGee (now Tronox) *Conceptual Site Model* report (ENSR, 2005). Figure**s G-3 and G-4** ~~-~~**are** ~~C-2 is an~~ isoconcentration plot**s** of Shallow Zone groundwater arsenic data compiled from the various sources associated with the BMI Plants area, the BRC CAMU area, and the BRC Eastside. The general spatial trends of the data for the proposed upgradient wells indicate that the concentrations are greater in wells to the south of the Site and decrease with increasing distance to the north-northeast. An exception to this spatial trend is for arsenic, where the concentration in well AA-UW-6 (102 µg/L 5th round, 161 µg/L Eastside 2009 groundwater sampling event), located to the northeast, was greater than in well AA-UW-1 (69.8 µg/L 5th round, 90.3 µg/L Eastside 2009 groundwater sampling event), located farther to the south toward the plants area. The source of this anomaly in the data spatial trend is unknown but may be attributable to the spatial variability of the natural arsenic content of geologic materials in the Site vicinity. **Wells AA-UW-1, -2, -4, -5, and -6 are installed in Layer 2 of the Shallow Zone (screened in the TMCf only). Wells AA-01, AA-27, and AA-UW-3 are screened in Layer 1 (Qal only). Because the background metals concentrations vary by lithologic unit, metals concentrations detected in groundwater samples from the wells would be expected to be reflective of the well screen layer.**

As with wells AA-01 and AA-27 discussed above, the distribution of the data indicate that these chemicals may be moving from off-site locations onto the Site. The source of these chemicals in groundwater may be the historical operations in the BMI plants area. ~~In the case of arsenic, the BMI plants area is an off-site source.~~

2.4.6.3 Maximum Contaminant Levels

Data for groundwater samples collected from the proposed upgradient wells over the six monitoring events were compared to federal maximum contaminant levels (MCLs) (Tables ~~4b~~ **5b** and ~~5b~~**6b**) for analytes that have no BCLs. TDS, sulfate, and chloride are the primary analytes detected above secondary MCLs; aluminum, iron, and manganese were also measured over the MCL but at a much lower frequency.

TDS in monitoring wells AA-UW-4 and AA-UW-6 exceeded ten times the secondary MCL (i.e., greater than 5,000 mg/L) in the 5th round, but the Eastside 2009 groundwater sampling event data showed lower TDS concentrations (3,700 mg/L for each well). The other proposed upgradient wells also had concentrations of TDS that exceed the TDS MCL during one or more monitoring events (Tables ~~4b~~ **5b** and ~~5b~~**6b**). However, TDS concentrations are broadly consistent between sampling rounds in the proposed upgradient wells (Tables ~~4b~~ **5b** and ~~5b~~**6b**).

The groundwater data from well boring AA-UW-6 do not appear to reflect unique historical impacts from former pond use. As shown on Tables ~~5a~~ **6a** and ~~5b~~**6b**, the detected perchlorate and chlorine concentrations are among the lowest measured. ~~Chloroform was detected at its lowest concentration in well AA-UW-6, and the measured~~ **S**~~s~~ulfate in well AA-UW-6 is roughly average for the proposed background wells. The TDS detection in this well, however, is among the highest TDS detections in the Shallow Zone. In addition, the arsenic was detected at 102 µg/L (5th round) and 161 µg/L (Eastside 2009 groundwater sampling event), which is the highest among the upgradient wells.

3. Summary and Conclusion

Proposed upgradient wells AA-01, AA-27, and AA-UW-1 through AA-UW-6 meet the criteria listed in Section 2 for designation as Shallow Zone upgradient wells for the Eastside area. Given the locations of the Site boundaries relative to the direction of groundwater flow and the physiographic and hydrogeologic features in the Site vicinity, there appear to be no alternative locations suitable for siting of Site upgradient wells.

Existing BRC data and modeling results that characterize groundwater flow conditions, current and historical site use, soil quality, site location, and groundwater quality support the selection of these wells for use as upgradient wells.

BRC proposes to use the data from the upgradient wells, where possible, for comparison to Site impacts and off-site impacts from the plants area and AMPAC. Appropriate data will be used as a screening tool in the BRC remedial alternatives study (RAS). If a particular analyte is detected at relatively elevated concentrations in the upgradient wells, compared to background or on-site/off-site data, then that well/analyte may be excluded from further analysis if the impacts are determined to be due to past BRC Site operations. However, that same well can still be used for data comparisons and decision-making for other analytes detected at relatively low concentrations compared to background or on-site/off-site impacts.

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